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on September 7, 2000

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09/07/00
Date of Signature

PATENT
#99-0334-UNI
Case #F3238(C)

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SEP 11 2000
PATENT & TRADEMARK OFFICE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Bakker et al.

Serial No.: 09/577,306

Filed: May 24, 2000

For: PROCESS AND APPARATUS FOR PRODUCTION OF A FROZEN FOOD PRODUCT

Edgewater, New Jersey 07020
September 7, 2000

SUBMISSION OF PRIORITY DOCUMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Pursuant to rule 55(b) of the Rules of Practice in Patent Cases, Applicant(s) is/are submitting herewith a certified copy of the United Kingdom Application No. 9912629.4 filed May 28, 1999, upon which the claim for priority under 35 U.S.C. § 119 was made in the United States.

It is respectfully requested that the priority document be made part of the file history.

Respectfully submitted,

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Dated 27 April 2000

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Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

28 MAY 1999

1.	Your reference	F3238(C) /rkk
2.	Patent application number *(The Patent Office will fill in this part)*	9912629.4
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	UNILEVER PLC UNILEVER HOUSE, BLACKFRIARS LONDON, EC4P 4BQ
	Patents ADP number *(if you know it)*	16280021
	If the applicant is a corporate body, give the country/state of its incorporation	UNITED KINGDOM
4.	Title of the invention	PORCESS AND APPARATUS FOR PRODUCTION OF A FROZEN FOOD PRODUCT
5.	Name of your agent *(if you have one)*	KIRSCH Susan Edith
	"Address for Service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	PATENT DEPARTMENT, UNILEVER PLC COLWORTH HOUSE, SHARNBROOK BEDFORD, MK44 1LQ
	Patents ADP number *(if you know it)*	16280033

6.	If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7.	If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application	Date of filing *(day/month/year)*

8.	Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body.* *See note (d))*	YES

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Continuation sheets of this form	
Description	7
Claim(s)	2
Abstract	1
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Priority Documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
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11. I/We request the grant of a patent on the basis of this application.

Signature(s) Date: **28 May 1999**

Sandra Jane EDWARDS, Authorised Signatory

12. Name and daytime telephone number of person to contact in the United Kingdom — **Ravinder K Kundra, Tel 01234 22 2439**

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Process and apparatus for production of a frozen food product

Technical field of the invention

The present invention relates to a process and an apparatus for the production of a frozen food product and more particularly an ice cream.

Background of the invention

Screw extruders such as single and twin screw extruders have been widely used and for a long time in the food industry, for example in the production of cereal based products. More recently, it has also been proposed to use single or twin screw extruders in the freezing of ice cream.

EP713650 discloses a process and an apparatus for extruding aerated frozen products wherein a twin screw extruder is used. The characteristic of the screws in the extruder is that they have a length over diameter ratio of between 30 and 60. It is not disclosed whether the diameter which is referred to is the diameter of the core of the screw or the diameter of the core of the screw plus its pitch. EP0808577 discloses a similar process and apparatus but whilst uses a single screw extruder having the same geometry.

EP561118 discloses a process and an apparatus for manufacturing frozen edible foams such as ice cream wherein a twin screw extruder is used. The geometry of the screw is defined by a (channel depth/channel width) ratio of approximately 0.1 and a pitch angle of between 22 and 30 degrees.

WO97/26800 discloses a process and an apparatus for manufacturing frozen edible foams such as ice cream wherein a single screw extruder is used. The geometry of the screw is defined by a (length of the screw/ inner diameter of the extruder barrel) ratio of between 5 and 10 a (pitch/external screw diameter) ratio of 1 to 2 and a (external diameter of the screw/inner diameter of the screw) of 1.1 to 1.4. According to the drawings, the screw has a single thread start.

One of the big problems faced when using an extruder for the manufacture of ice cream is that a temperature as low as possible is required while keeping an acceptable flow. Now, the lower the temperature the bigger the flow resistance which by generating frictions re-heats the product which is being cooled and limits the temperature which is thus achieved. There is therefore a need for optimising the geometry of the extruder in such a way that the increase in friction which is generated when the product is cooled is minimised in order to reach a temperature as low as possible.

It has now been found that it is possible to dramatically increase the performance of an extruder when used in the manufacturing of ice cream by;

- operating with a pitch angle which is outside what has been used up to now in the manufacturing of ice cream,
- operating with screws which have more than one thread start whereas up to now screws with only one thread start screws have been disclosed,
- operating with extruders which are much shorter than what has been used up to now.

Tests and Definitions

1. Screw parameters

An extruder screw is defined by different parameters which need accurate definitions. In order to help in the definition of such parameters, reference is made to Fig.1 which discloses a typical screw fitted in a single screw extruder. Such an extruder is, for example, described in Engineering principles of plasticating extrusion - Zehev Tadmor - Krieger Publishing Company - 1978 - pages 39 to 45.

Screw length : LT

Pitch length: Sp (axial distance of a full turn (screw lead))

Thread starts: A screw can have more than one helix, in the rest of the description, each helix is called a thread start and the number of thread starts is 'n'. On Fig.1, the screw which is represented has two thread starts.

Channel depth: H (the distance between the root of the screw and the inner surface of the barrel less the radial clearance between the crest of the screw and the inner surface of the barrel)

Screw diameter De: Diameter of the barrel less the distance between the root of the screw and the inner surface of the barrel.

Pitch angle: Arctg(Sp/pi.De)

Channel width: wc (distance between the flights along a helical line which is perpendicular to the flight).

Summary of the invention

It is a first object of the present invention to provide an extruder comprising an extruding screw characterised by between 2 and 5 thread starts and a pitch angle of between 28 and 45 degrees, preferably between 32 and 42 degrees. Preferably the extruder comprises cooling means, more preferably, the cooling means are constituted by a cooling circuit wherein a cooling liquid is circulated. Even more preferably the cooling liquid is ammonia or nitrogen.

It has been found that the higher the number of thread starts, the higher the ammonia temperature required to achieve a given temperature at the output of the extruder, showing that increasing the number of thread starts leads to a better cooling effect.

Preferably the (H/wc) ratio is between 0.1 and 0.2

Preferably also, the screw comprises between 3 and 4 thread starts and the cooling liquid is ammonia.

Preferably also the screw has a De/LT ratio of between 2 and 10, more preferably between 2 and 5, even more preferably between 2 and 4. It has been found that, and contrary to what is suggested by the prior art, not only there is no need for going for long screws but it is effectively a waste of energy. If the screw is too long, the heat dissipation due to the friction caused by the increase in viscosity generated by the cooling tends to equate the cooling effect and the two phenomenon (cooling and heat dissipation) equilibrate and there is no cooling taking place at the end of the screw. Nevertheless, the friction existing at the end of the screw, where no cooling takes place, requires

additional torque to keep the screw rotating for no benefit to the process or the end product.

Preferably also, the extruder is a single screw extruder.

It is a second object of the invention to provide extruder comprising an extruding screw characterised by a pitch angle of between 28 and 45 degree, preferably between 32 and 42, and a Lt/De ratio of between 2 and 10, preferably 2 and 5, more preferably 2 and 4.

It is a third object of the present invention to provide a process for the manufacturing of frozen food product, wherein a food composition is mixed, aerated and cooled down to a temperature of between -4°C and -7°C and then processed in an extruder for further cooling down to a temperature of between -12° and -20°, characterised in that the extruder comprises an extruding screw having 2 to 5 thread starts and a pitch angle of between 28 and 45 degrees, preferably between 32 and 42 degrees, and further comprises cooling means, the cooling means being preferably constituted by a cooling circuit wherein a cooling liquid is circulated.

Preferably the cooling liquid is selected within the group consisting of ammonia or nitrogen. More preferably, the screw comprises between 3 and 4 thread starts and the cooling liquid is ammonia.

Preferably also the screw has a LT/De ratio of between 2 and 10, more preferably between 2 and 5, even more preferably between 2 and 4.

Preferably also, the extruder is a single screw extruder.

It is a fourth object of the invention to provide a process for the manufacturing of frozen food product, wherein a food composition is mixed, aerated and cooled down to a temperature of between -4° and -7° and then processed in an extruder for further cooling down to a temperature of between -12° and -20°, characterised in that the extruder comprises cooling means, the cooling means being preferably constituted by a cooling circuit wherein a cooling liquid is circulated and further comprises an extruding screw having a pitch angle of between 28 and 45 degrees, preferably between 32 and 42 degrees, and a Lt/De ratio of between and 2 and 10, preferably between 2 and 5, more preferably between 2 and 4.

Preferably the cooling liquid is selected within the group consisting of ammonia or nitrogen. Preferably also the screw comprises between 3 and 4 thread starts and the cooling liquid is ammonia.

Detailed description of the invention

The present invention will be further described in the following examples and by reference to the drawing wherein;

. Figure 1 represents a schematic view of an extruder comprising an extruding screw.

An ice cream premix having the following composition;
Total fat: 8.4%
Stabiliser emulsifier: 0.56%
Added Sugars: 16.8%
Total protein : 3.5%
Total solids: 34.9%
Of which Milk solids (non fat): 9.55%
Water: the rest

was aerated up to an overrun of 100% and cooled down to a temperature of -4.5°C using conventional means for subsequent processing.

The cooled product obtained was then conveyed to a single screw extruder according to the invention for subsequent extrusion. The product was extruded at 500 litre ice cream per hour at a torque of 1200 Nm in a single screw extruder cooled with ammonia.

Various screw geometries were tested and the results are summarised in the following table.

Thread starts	Pitch angle	Channel Depth	Outlet temperature	Rotational speed	Ammonia temperature
2	12	15	-11	28	-27
3	14	17	-11.4	29	-27
4	19	10	-11.5	23	-25
4	28	8	-11.7	17	-25
4	35	8	-12.2	14	-24
4	40	11	-13.3	13	-25
6	40	7	-12.7	16	-23
6	40	10	-13	14	-23
6	40	5	-11.9	19	-22

Claims

1. Extruder comprising an extruding screw, said extruding screw being characterised by between 2 and 5 thread starts and a pitch angle of between 28 and 45 degrees.

2. Extruder according to claim 1 comprising cooling means, the cooling means being preferably constituted by a cooling circuit wherein a cooling liquid is circulated.

3. Extruder according to claim 2 wherein cooling liquid is selected within the group consisting of ammonia or nitrogen.

4. Extruder according to claim 3 wherein the screw comprises between 3 and 4 thread starts and the cooling liquid is ammonia.

5. Extruder according to claim 1 wherein the screw LT/De ratio of between 2 and 10, preferably between 2 and 5, more preferably between 2 and 4.

6. Extruder according to any preceding claim wherein the extruder is a single screw extruder.

7. Extruder comprising an extruding screw characterised by a pitch angle of between 28 and 45 degrees, preferably 32 and 42 degrees, and a Lt/De ratio of between and 2 and 10, preferably between 2 and 5, more preferably between 2 and 4.

8. Extruder according to claim 7 comprising cooling means, the cooling means being preferably constituted by a cooling circuit wherein a cooling liquid is circulated.

9. Extruder according to claim 8 wherein the cooling liquid is selected within the group consisting of ammonia or nitrogen.

10. Extruder according to claim 9 wherein the screw comprises between 3 and 4 thread starts and the cooling liquid is ammonia.

11. Extruder according to any preceding claim 7 to 10 wherein the extruder is a single screw extruder.

12. Process for the manufacturing of frozen food product, wherein a food composition is mixed, aerated and cooled down to a temperature of between -4° and -7° and then processed in an extruder for further cooling down to a temperature of between -12° and -20°, characterised in that the extruder comprises cooling means, the cooling means being preferably constituted by a cooling circuit wherein a cooling liquid is circulated and further comprises an extruding screw having a pitch angle of between 28 and 45 degrees, preferably between 32 and 42 degrees, and a Lt/De ratio of between and 2 and 10, preferably between 2 and 5, more preferably between 2 and 4.

Abstract

The performance of an extruder when used in the manufacturing of ice cream by operating with a pitch angle of between 28 and 45 degrees with screws which have more than one thread start.

Fig. 1